given thrice daily for pretreatment against nerve agent) reduced thermoregulatory vasodilation during moderate exercise in a warm environment,[130] and may potentially impair thermoregulation under more severe heat-stress conditions.

Both chronic and acute disorders may reduce heat tolerance. Untreated hypertension impairs the circulatory responses to heat stress. The effect of treated hypertension on heat tolerance is not known, but there are theoretical reasons for suspecting that some drugs used to treat hypertension may impair heat tolerance.[121] Congestive heart failure substantially impairs both sweating and the circulatory responses to heat stress, and moderate heat exposure worsens the signs and symptoms of congestive heart failure.[53] Neurological diseases involving the thermoregulatory structures in the brainstem can impair thermoregulation. Although hypothermia may result, hyperthermia is more usual and typically is accompanied by loss of sweating and the circadian rhythm. Several skin diseases impair sweating sufficiently that heat exposure, especially combined with exercise, may produce dangerously high body temperatures. Ichthyosis and anhidrotic ectodermal dysplasia can profoundly limit the ability to thermoregulate in the heat. In addition, heat rash (miliaria rubra)[131] and even mild sunburn[132] impair sweating and may reduce tolerance to exercise in the heat. The thermoregulatory effects of heat rash may persist for a week or longer after the appearance of the skin has returned to normal.[131]

SUMMARY

The body may be divided into an internal core, which includes the vital organs, and a superficial shell. Tissue temperature is fairly uniform throughout the core. Core temperature is regulated by the thermoregulatory system and is relatively unaffected by changes in environmental conditions. The temperature of the shell is not uniform, and varies both from point to point within the shell and with changes in environmental conditions. Most heat exchange between the body and the environment occurs at the skin surface, by convection, radiation, and evaporation. These three modes of heat exchange depend on the temperature and degree of wetness of the skin, and on environmental conditions including air movement, the temperature and moisture content of the air, and the temperatures of radiating surfaces in the environment.

The body controls heat flow between core and skin by controlling skin blood flow. Changes in skin blood flow affect skin temperature, and thus controlling skin blood flow provides a means of influencing heat exchange with the environment by convection and radiation. However, the effect of skin blood flow on heat exchange with the environment is limited in the heat, and the body cannot dissipate heat by convection and radiation if the environment is warmer than the skin. Secretion of sweat wets the skin, and sweating increases evaporative heat loss, as long as the environmental conditions allow the sweat to evaporate. Large amounts of heat can be dissipated by evaporation of sweat: sweat rates of 1L/h (corresponding to a rate of heat loss of about 675 W) can be sustained for many hours, and higher rates can be achieved for shorter periods.

Sweating and skin blood flow are controlled via the sympathetic nervous system, and these responses are graded according to elevations in core and skin temperatures. The operation of the thermoregulatory system is governed by the thermoregulatory set point, which we may think of as the setting of the body's "thermostat." The set point varies in a cyclical fashion, with an amplitude of 0.5 to 1.0 Centigrade degrees, according to time of day and, in women, the phase of the menstrual cycle, and it is elevated during fever.

Vigorous exercise can increase heat production within the body 10-fold or more. Because of the levels of skin blood flow needed for high rates of heat dissipation in a hot environment, exercise and heat dissipation make competing demands on the cardiovascular system. Moreover, if water and electrolytes lost as sweat are not replaced, plasma volume eventually is depleted. For these reasons, heavy exercise in the heat may seriously challenge cardiovascular homeostasis.

Heat tolerance is increased by aerobic exercise training and by acclimatization to heat. Acclimatization to heat develops quickly: the effectiveness of the heat-dissipating arm of the thermoregulatory system and exercise performance in the heat show pronounced improvements within a week. Conversely, poor physical fitness and certain disease states and drugs are associated with impairment of the thermoregulatory responses.

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